STANDARD TEST METHOD FOR EVALUATING TRIBOELECTRIC CHARGE GENERATION AND DECAY

TEST REPORT

Standard Test Method for Evaluating Triboelectric Charge Generation and Decay

ISSUED BY

National Aeronautics and Space Administration
Kennedy Space Center
Spaceport Engineering & Technology
Materials Science Laboratory

PREPARED BY: ______________________________
J. Mica Parenti/YA-F1-T

CONTRIBUTORS: R. H. Gompf

1.0 SCOPE

This method describes the tribo-electric device used at Kennedy Space Center (KSC) to test the electrostatic properties of materials, including the preparation and conditioning of test samples, the procedure used for testing, the data gathering system, and the procedure used to verify measurement system accuracy. This method is especially applicable for testing thin plastic films, foams, tapes, cloth fabrics, solid surfaces up to 0.5 in. thick, and surface coatings such as paint or anti-static coatings applied to thin solid samples.

2.0 SIGNIFICANCE AND USE

2.1 Attention has been given to the problem of static electricity because of its ability to damage or destroy certain semiconductor devices, unexpectedly initiate ordnance devices, ignite explosive atmospheres, and surprise workers doing critical jobs causing undesirable consequences and injuries to occur. These hazards associated with electrostatic discharge (ESD) are a continuing safety and financial concern to the scientific, aerospace, and industrial communities. Thin materials like plastic films, foams, and tapes are some of the materials most likely to develop damaging static charge buildup.

2.2 This test method may be used to evaluate the static electrical charge generated and the rate of discharge from materials under controlled environmental conditions.

3.0 SUMMARY OF METHOD

Specimens cut from the material to be tested are preconditioned to the required test environment for 24 hours prior to testing. The test specimen is then mounted in the sample holder and the system is ionized bringing everything to zero potential. Then the rubbing wheel covered with felt polytetrafluoroethylene (PTFE) contacts the specimen for 10 seconds, and any charge generated and its decay rate are monitored on a digital Dewetron 3000 data acquisition scope.

4.0 APPARATUS

4.1 The Triboelectric Device

Photographs of the complete test device and associated engineering drawings for its components are shown in Figures 1 through 12. It consists of a grounded aluminum frame with two cutouts in the front faceplate. The lower right opening exposes the static Keithley model 2501 detecting head. The upper left cutout is the pass-through for the rubbing wheel used to generate the triboelectric charge. The rubbing wheel is attached to a 1/8 HP electric drive motor with a speed control unit set at 200 rpm. A manual control lever is used to control the forward sliding motion of the motor/wheel assembly and provide gentle intimate contact control with the test specimen at the proper time. The rubbing force of the wheel against the sample is held constant during the test using a weight and pulley system. In this system a cord is attached to the motor assembly, run over a pulley, and a 3-pound weight is attached to the end of the cord. The test specimen is mounted in the grounded, aluminum sample holder in a taut condition. The sample holder is free to rotate about a fixed point facilitating rapid movement of the specimen from the rubbing wheel to the detector head.

4.2 Rubbing Wheels

Each rubbing wheel has a diameter of 5 inches. The standard wheel used has a phenolic back, 1-inch thick foam cushion, and felt PTFE rubbing surface (Figure 11). The felt surface is used for most material testing configurations. A wheel with a solid PTFE rubbing surface with a convex surface radius of 12 inches is used on cloth fabrics, “wet” anti-static coatings, and test surfaces that would otherwise damage or contaminate the felt PTFE surface. Other special wheel configurations, such as a soft wool surface, can be made if needed.

4.2.1 Cleaning Rubbing Wheels

Some materials may contain or be coated with a substance that will come off of the sample and be deposited on the rubbing wheel. This contamination may then interfere with the accuracy of subsequent testing. When this occurs, simply wipe the solid PTFE rubbing wheel with a clean, lint-free cloth and reagent grade isopropanol. For the felt PTFE wheel, fill a small tray with distilled water and place the felt side down into the tray. Press down on the hard back of the wheel, compressing the foam backing so the water can be absorbed. Compress the wheel in this fashion a few times, then, with all of the water poured out, compress the foam again to remove the excess water from the wheel. Repeat the above step with reagent grade isopropanol. Place the wheel in an oven at about 150°F for at least 2 hours until completely dry. Before the wheels can be used again for testing, they must acclimate to the test conditions for at least 24 hours.

4.3 Data Gathering System

The generated charge on the test sample is measured using a Keithley Instruments Model 2501 static detecting head. The output of the detector is electrically connected to a Keithley Model 610 solid state electrometer. The detector head senses the electrostatic field and the electrometer generates a dc voltage proportional to the electrostatic field sensed. This voltage from the electrometer is then fed into a Dewetron 3000 data acquisition scope which displays the voltage on the Y axis verses the time setting on the X axis acquiring a total waveform sample in 7 seconds. The Dewetron 3000 data acquisition scope is triggered by a 9-volt battery connected to a micro-switch on the motor/slide assembly. This is accomplished when the rubbing wheel is retracted from the sample (ceasing charge generation), the Dewetron 3000 data acquisition scope is triggered marking the zero time point on the data display page as the time charge generation on the test ends. Data can then be retrieved from the display in voltage vs. time. If desired, the data waveform may be stored on 3.5-inch disk for PC spreadsheet analysis or may be plotted immediately on an Hewlett Packard Deskjet 710C printer connected to the Dewetron 3000 data acquisition scope.

5.0 PREPARATION OF TEST SPECIMENS

5.1 Cut one to three specimens, each 7 5/8 inches square, from the material to be tested. Protective gloves should be worn to prevent contamination of the testing surface.

5.2 Condition the test specimens at the desired test environment (temperature, relative humidity, and atmospheric pressure) for a minimum of 24 hours before testing.

6.0 TEST METHOD

Once specimens are conditioned, the procedure for testing is as follows:

1. Turn on electrometer and Dewetron 3000 data acquisition scope and allow 30 minute warm up.

2. Turn on 1/8 hp drill motor and verify speed of 200 rpm. Adjust speed if necessary.

3. Verify 3-pound weight is hanging free and moves freely with slide movement.

4. Verify Dewetron 3000 data acquisition scope and electrometer settings and change if needed.

5. Mount test sample in sample holder. This can be from one sample one side up to three samples two sides tested.

6. Extend rubbing wheel completely forward and turn on ionizer for at least 15 seconds to remove any residual static charge from the wheel and test sample.

7. Retract rubbing wheel.

8. Zero electrometer.

9. Raise sample holder in front of rubbing wheel cutout.

10. Move control levers to gently engage the rubbing wheels with the test sample and allow rubbing contact to continue for 10 seconds.

11. While wheel is in contact with the sample, arm the Dewetron 3000 data acquisition scope and unground the electrometer.

12. Quickly retract the rubbing wheel while simultaneously dropping the sample holder.

13. At the end of the sample period, all peak voltages and the voltages measured at 0.5, 1.0, 2.0, 3.0, 4.0, and 5.0 seconds will be recorded and can be stored on the Dewetron 3000 data acquisition scope as well as a 3.5-inch disk.

14. After each sample or set of samples is tested, a print out of the waveform, raw data, and a final report can be printed.

15. Repeat test with fresh sample beginning with step 4.

NOTE: Sequence of Steps 1 through 8 is not critical to test results.

7.0 SYSTEM CALIBRATION VERIFICATION

Because the electronics in the data gathering system are individually calibrated, an end-to-end calibration verification should be performed periodically to determine the reliability of the system as a integrated

whole. This system verification should be performed any time an electronic component is changed out or when the triboelectric system is dismantled and moved. In order to perform this operation, a verification test plate must be fabricated as shown in Figure 14. This verification test plate consists of a thin, metal disc fastened to a sheet of PTFE. The PTFE sheet is sized to prevent movement and electrical short of the disc while in the sample holder. A calibrated, high voltage dc power supply is also required.

7.1 Verification Method

1. Turn on electrometer and Dewetron 3000 data acquisition scope and allow 30 minute warm up.

2. Install test plate in sample holder with metal disk facing detector head. Make sure the metal disk is not in contact with any portion of the sample holder.

3. Verify power supply is OFF.

4. Clip grounded lead of supply to a metal portion of the sample holder.

5. Clip the hot lead of the supply to the screw lug on the back of the test plate.

6. Verify the settings on the electrometer and Dewetron 3000 data acquisition scope and make adjustments as necessary.

7. Set the power supply to desired test voltage.

8. Bring the rubbing wheel forward completely so that the Dewetron 3000 data acquisition scope can be triggered using the micro-switch circuit.

9. Arm the Dewetron 3000 data acquisition scope and unground the electrometer.

10. Retract rubbing wheel and immediately turn on power supply.

11. When scope waveform is captured, turn off power supply and disconnect leads from test plate.

12. Verify that the steady state voltage on the Dewetron 3000 data acquisition scope agrees with the voltage output of the supply.

13. Adjust detector head spacing (forward or back) from test plate as necessary, repeating steps 3 through 12, until the system accurately agrees with the voltage from the power supply.

8.0 ELECTROSTATIC ACCEPTANCE CRITERIA

Five (5) seconds after termination of charge generation, the electrostatic voltage generated by the triboelectric device shall be 350 volts or less. Test results are valid only for the color pigment associated with the material being evaluated. The standard test environment shall be 75±5°F at 30% and 45% relative humidity. Special environmental conditions may be provided as needed.

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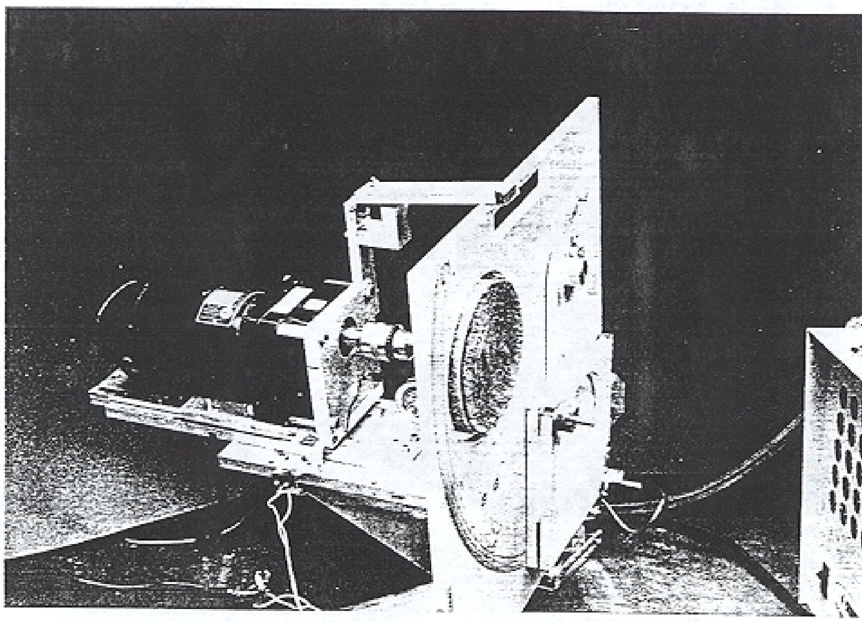

FIGURE 1
TRIBOELECTRIC TEST APPARATUS

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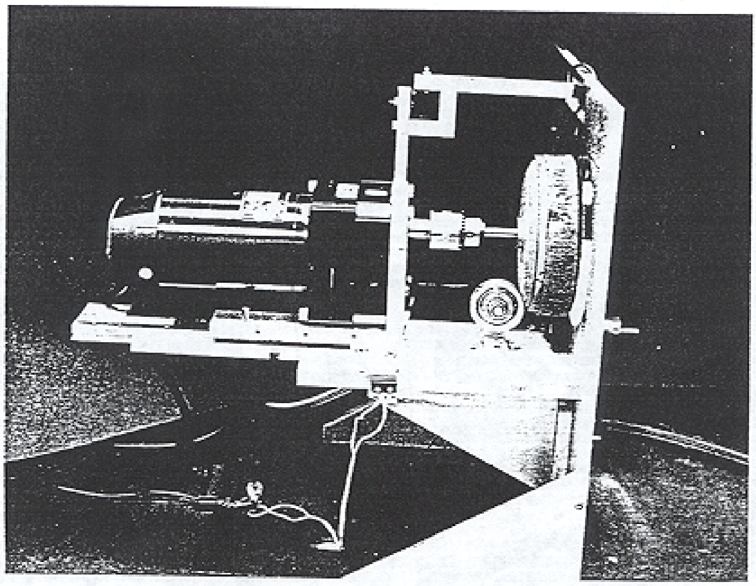

SIDEVIEW

FIGURE 2
TRIBOELECTRIC TEST APPARATUS

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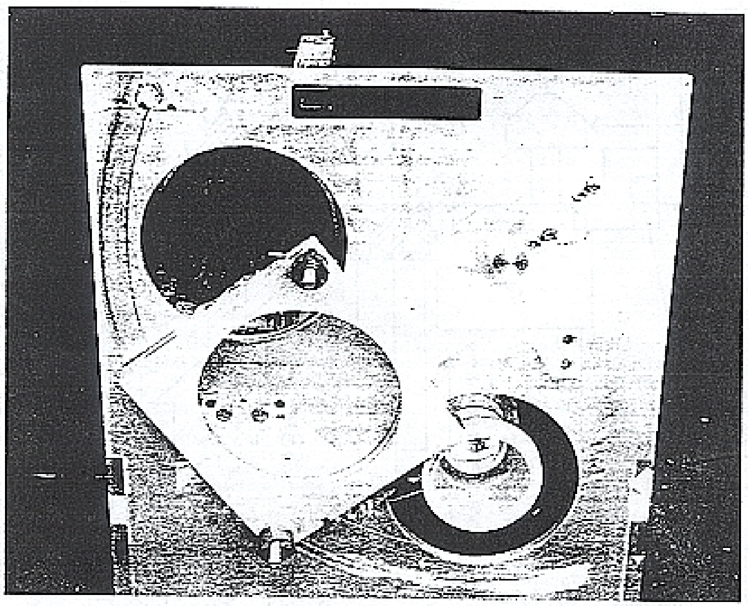

FRONTVIEW

FIGURE 3
TRIBOELECTRIC TEST APPARATUS

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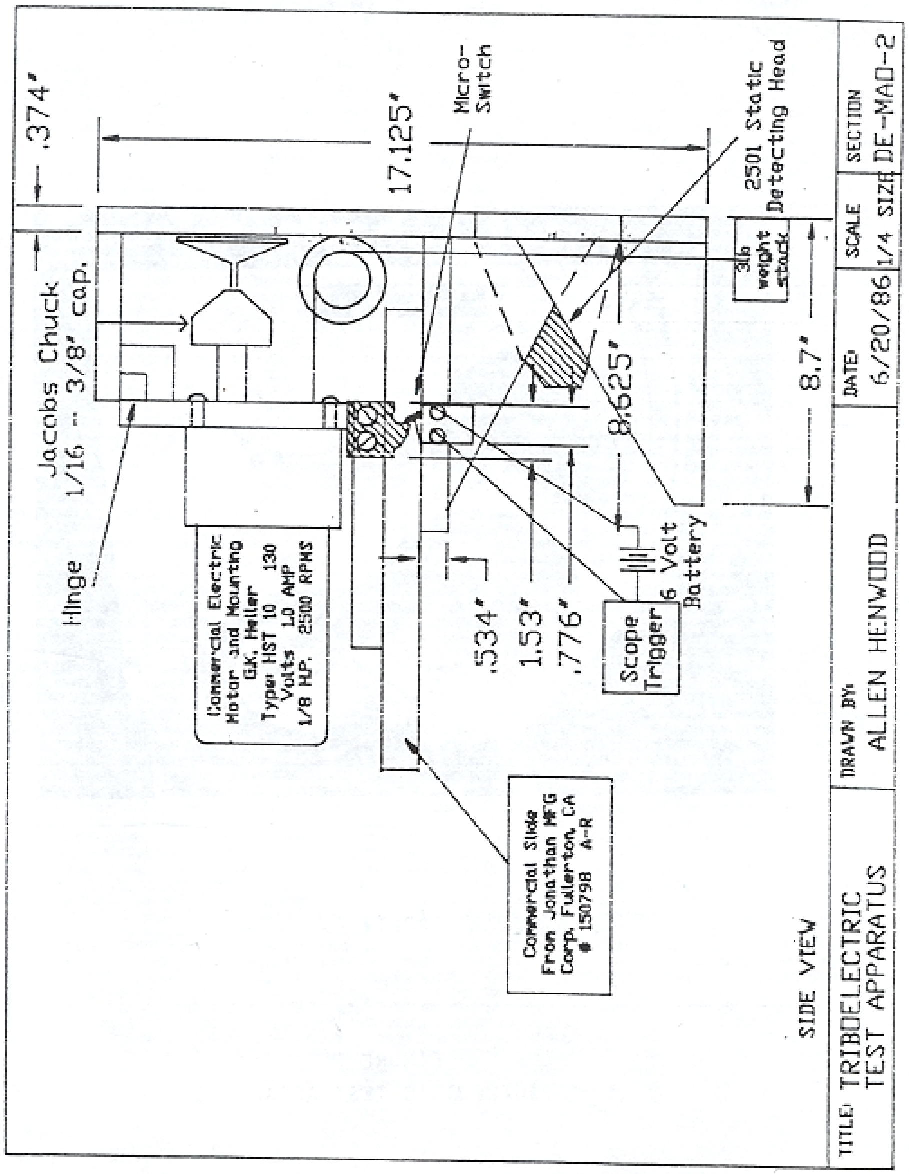

FIGURE 4

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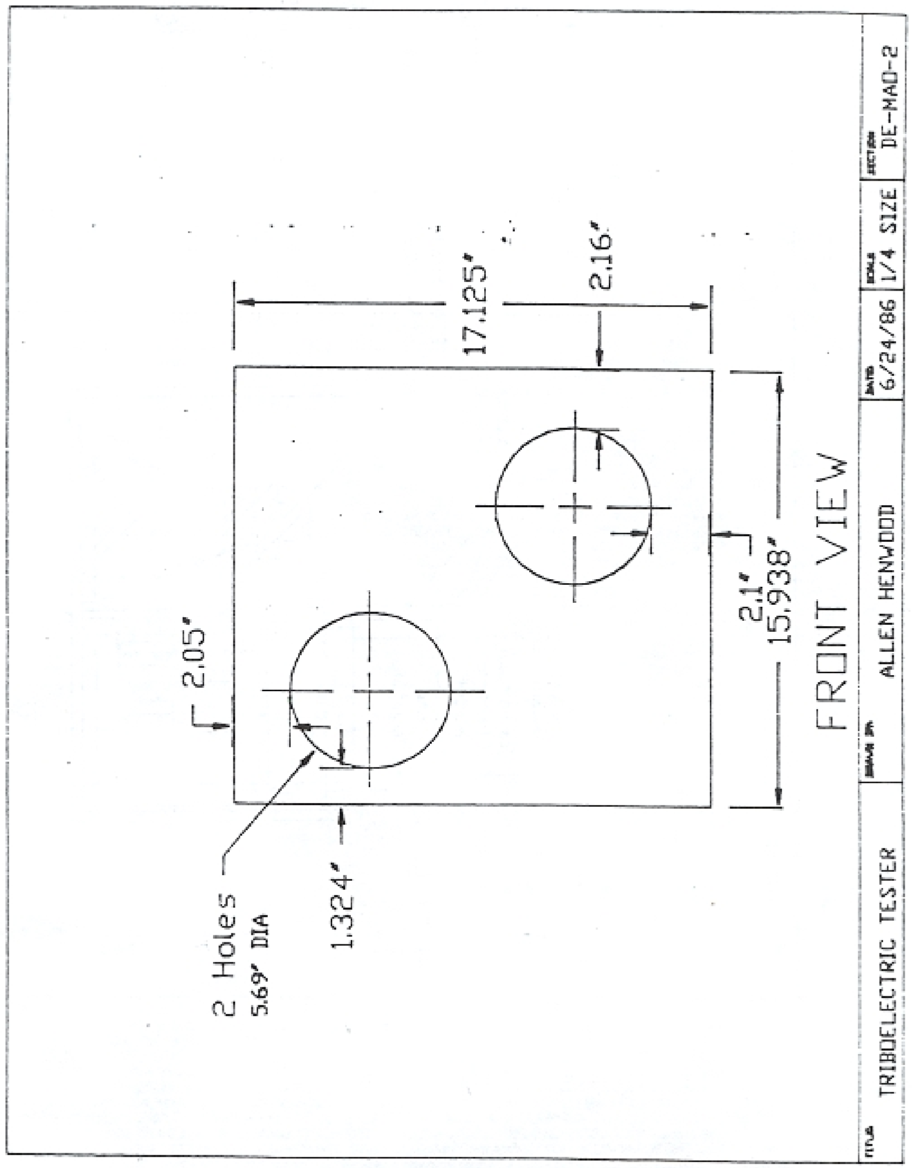

FIGURE 5

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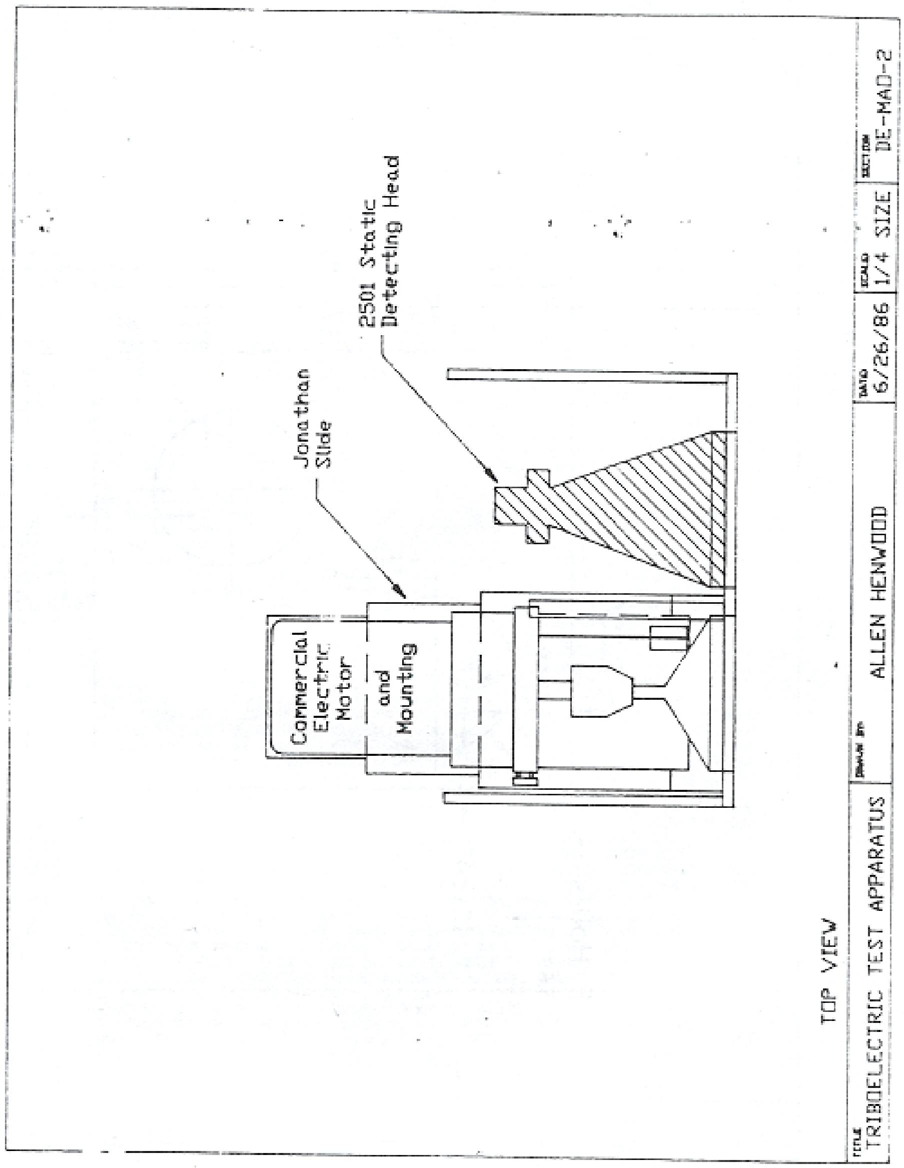

FIGURE 6

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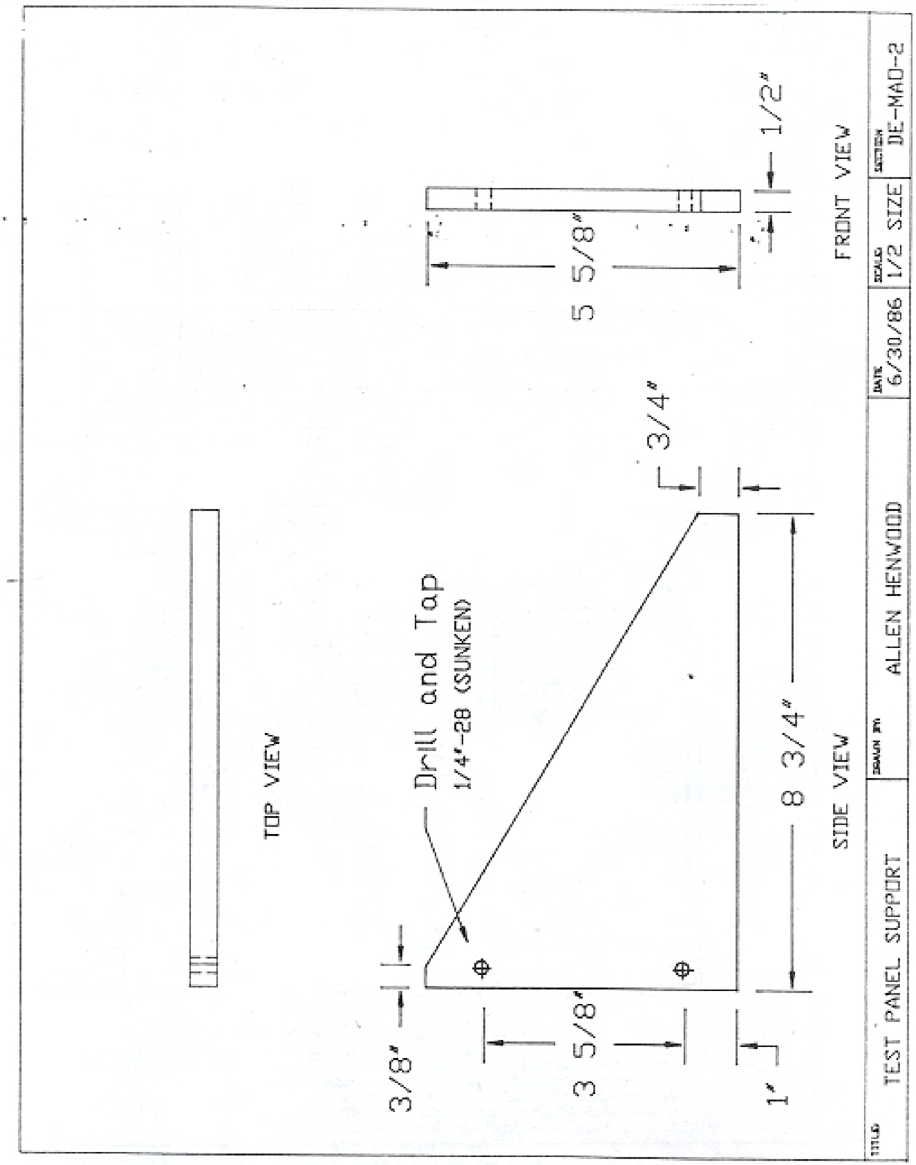

FIGURE 7

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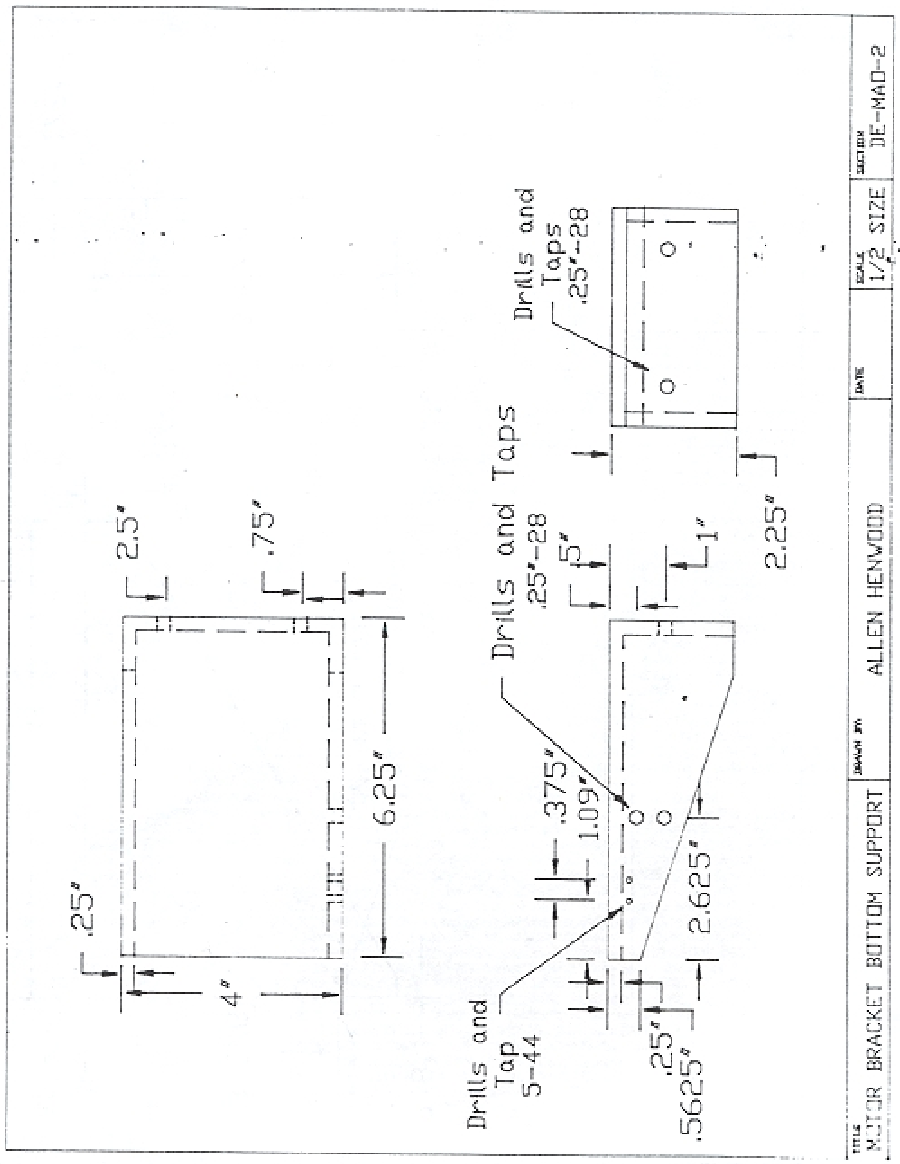

FIGURE 8

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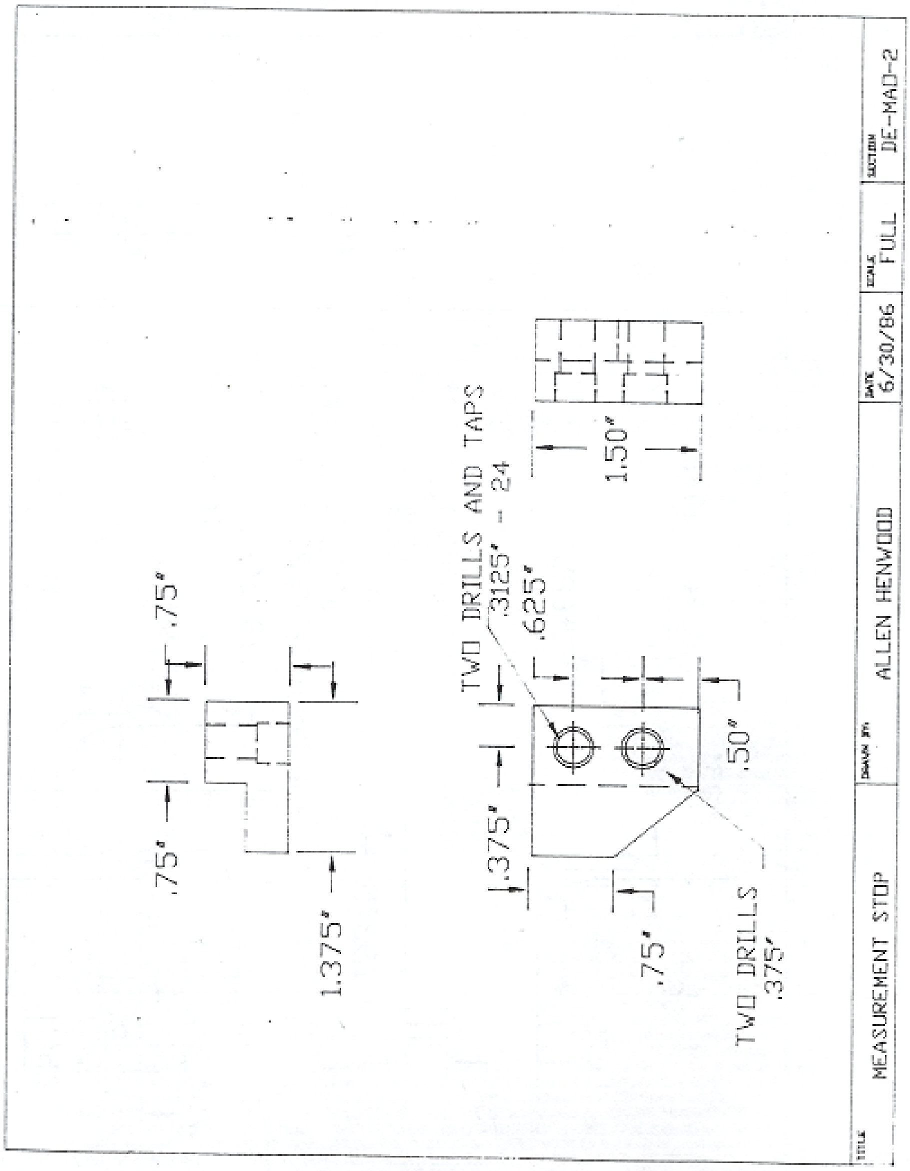

FIGURE 9

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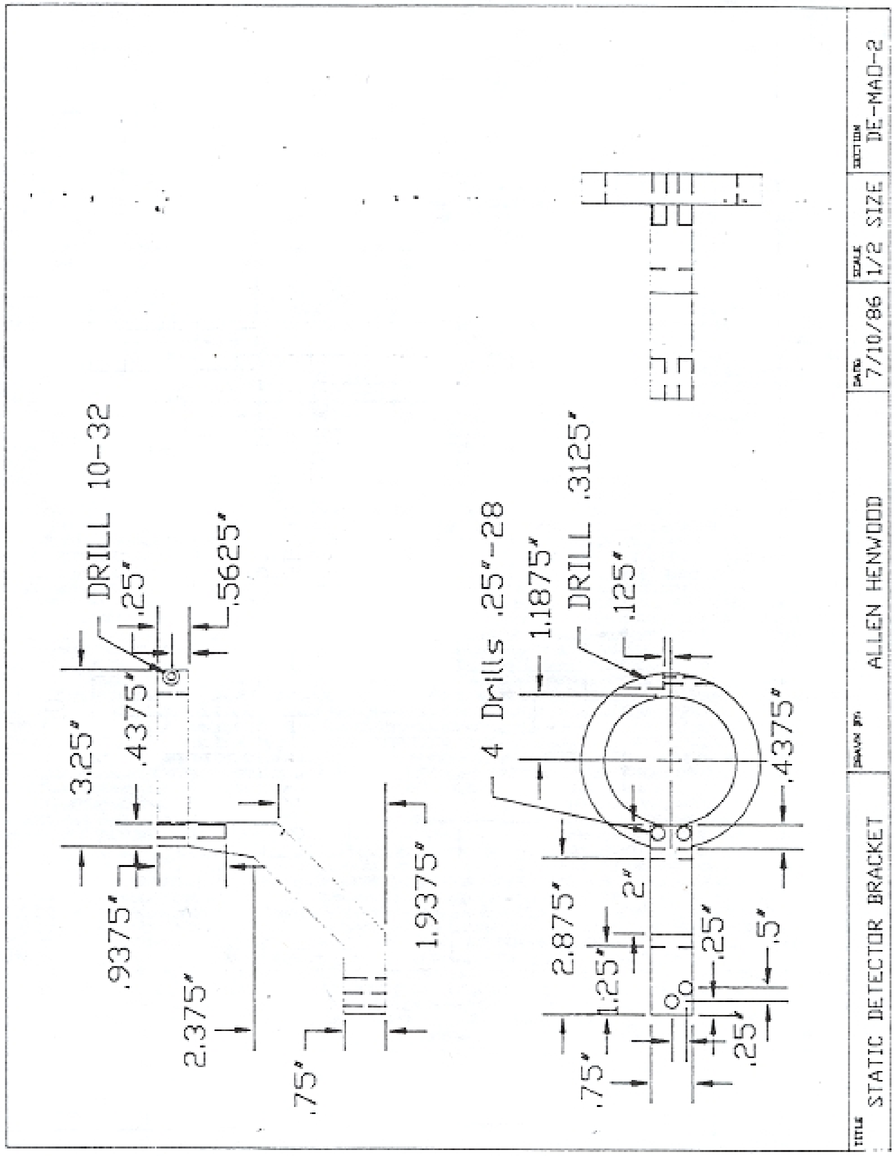

FIGURE 10

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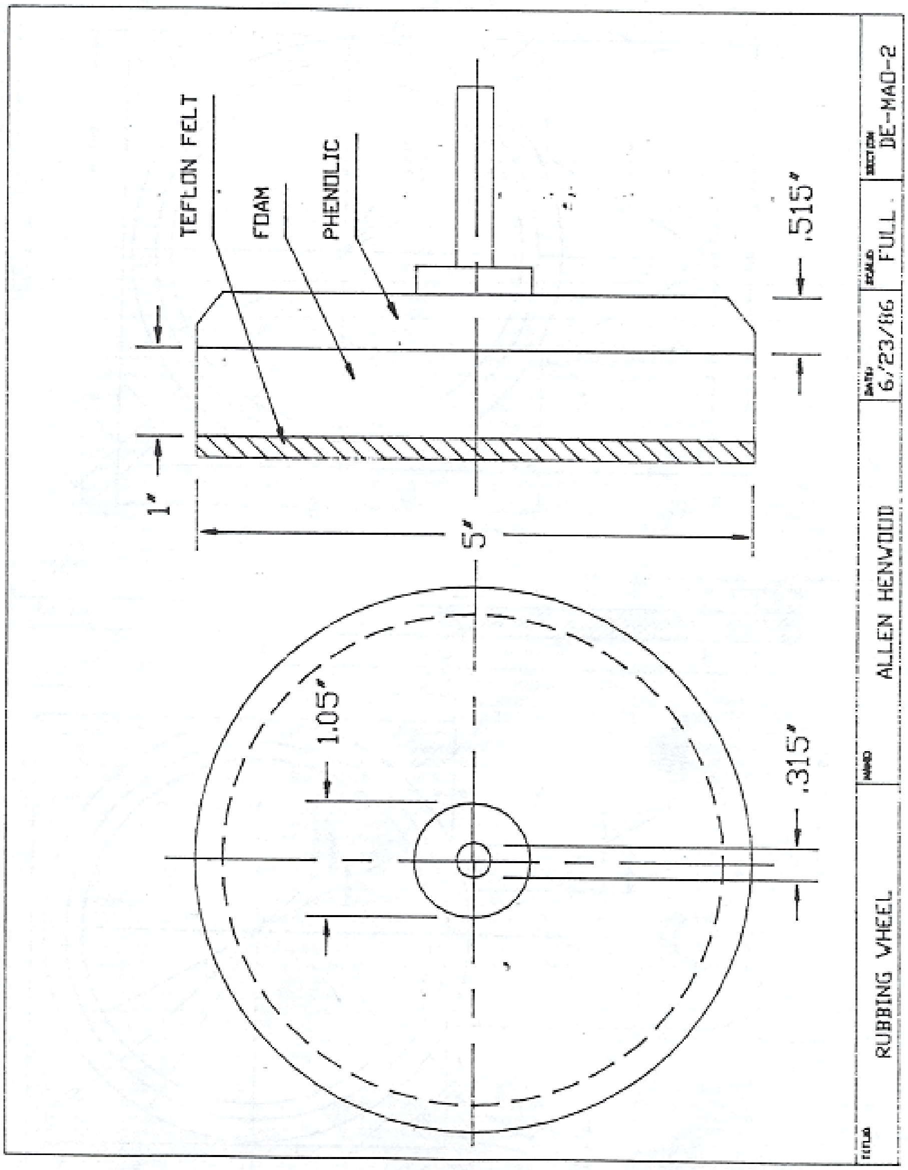
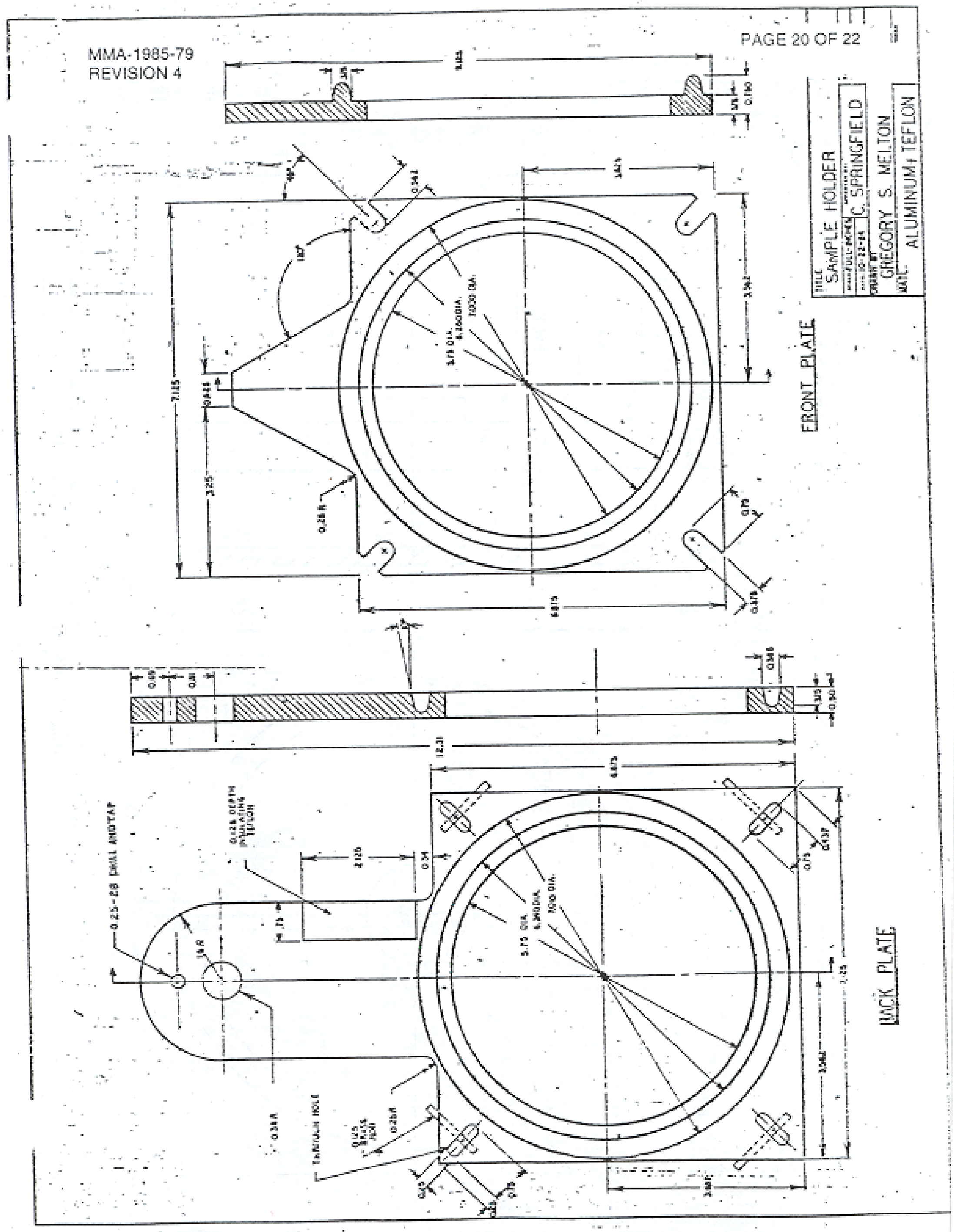


FIGURE 11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SAMPLE HOLDER
C. SPRINGFIELD
GREGORY S. MELTON
ALUMINUM, TEFLON
FRONT PLATE
BACK PLATE

FIGURE 12

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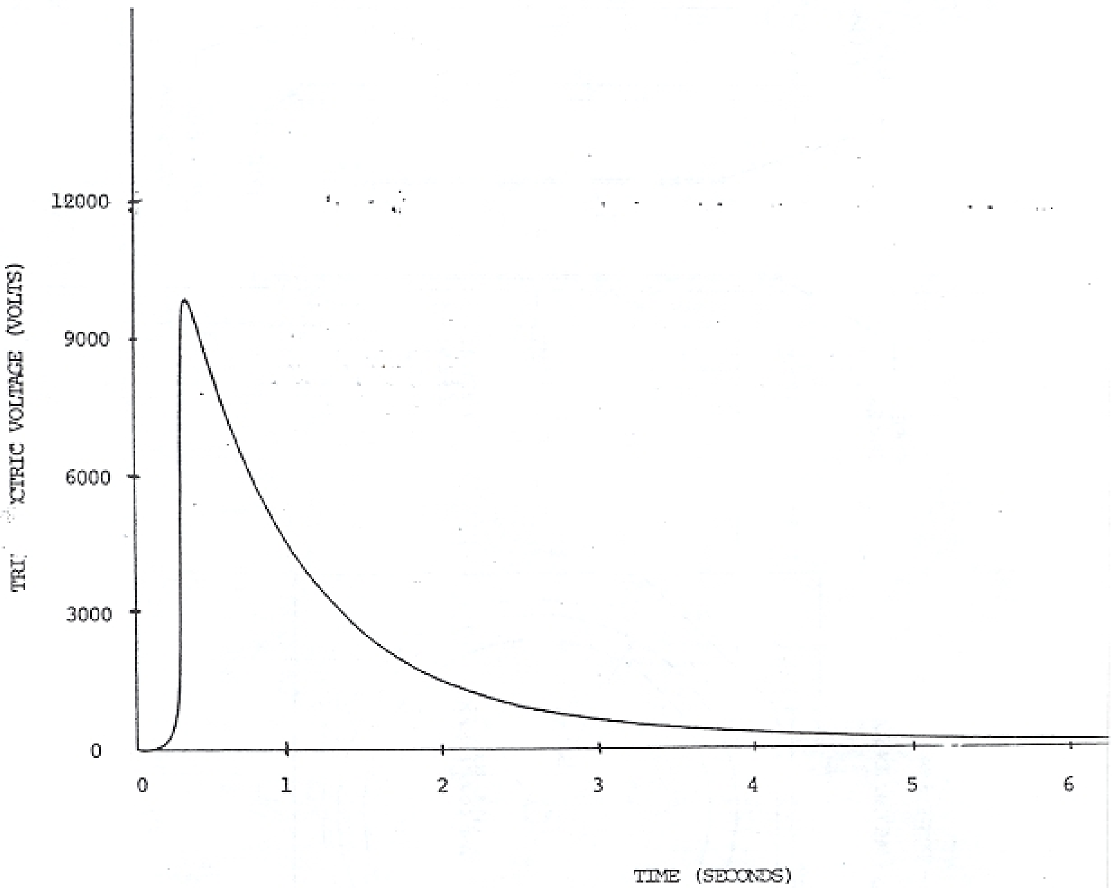

FIGURE 13
TRIBOELECTRIC PLOT X VS Y

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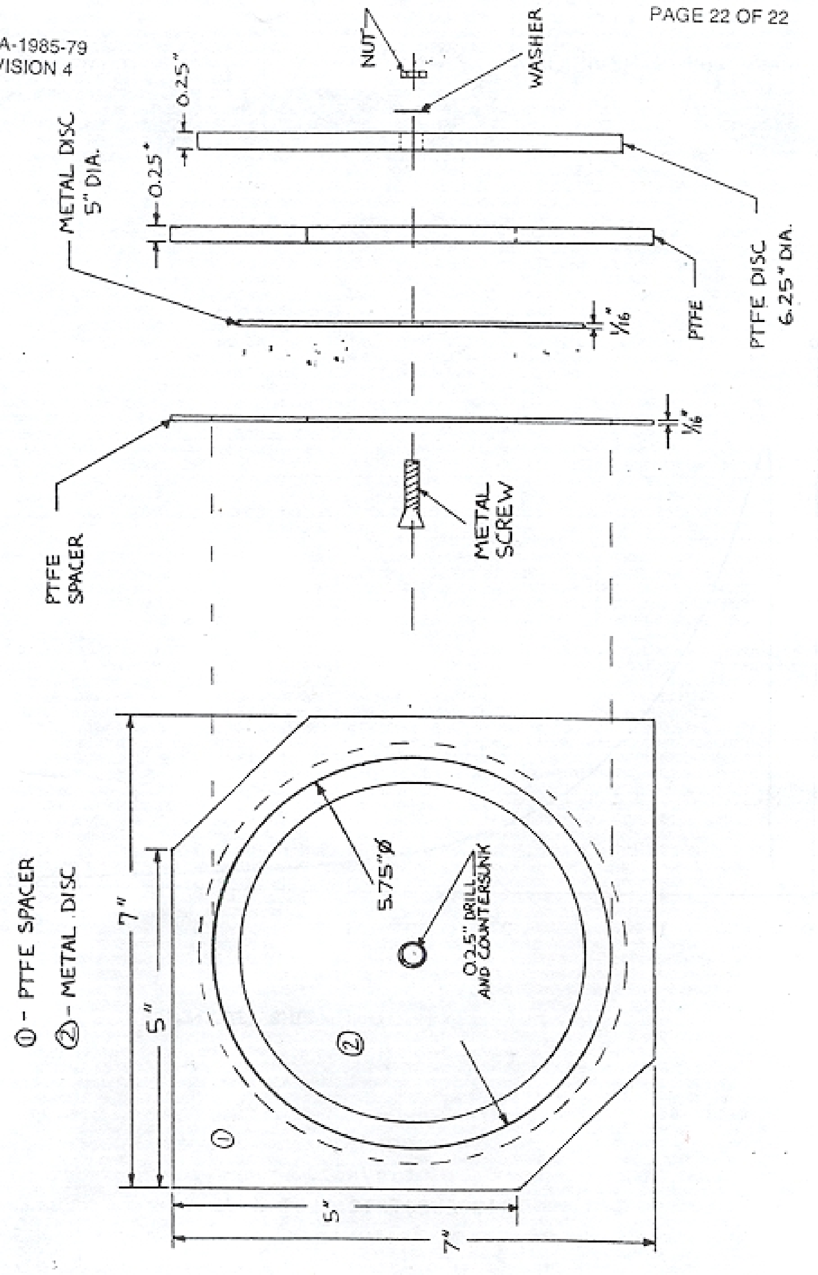

FIGURE 14

HALF-SCALE DRAWING OF CALIBRATION VERIFICATION DEVICE